Supporting Information

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Ecological Relevance of Fish Functional Traits

Fish play important roles in aquatic ecosystems, mainly through regulation of food webs and nutrient cycling (1). The ability of each species to impact these ecosystem processes depends on several biological traits linked to food acquisition and locomotion (2, 3). For instance, the trophic impact of a species depends on its foraging activity: i.e., which prey items it targets, when, and how many. For instance, an ambushing solitary benthic predator (e.g., scorpionfish) will not have the same trophic impact as a mobile pelagic gregarious predator (e.g., barracuda) on small fishes. Therefore, describing fish functional niche requires considering a set of complementary functional traits. Here, we selected six traits that describe the main facets of fish ecology (4–7) and that are available for a wide range of reef species.

Body Size. Body size has a primary role in defining fish ecological niche (8, 9). More specifically, size determines energy needs through the amount of energy required per unit of body mass (10) and constrains prey–predator relationships because mouth gap scales with body size (11). Size also influences growth rate, with small fishes growing faster than larger ones (12). Mortality rate tends to be higher for smaller fishes (10) whereas temperature tolerance is at least partly related to body size in reef fishes (13).

Diet. Diet, like size, is an essential component of reef fish ecological niche as indicated in general reviews (14–17). In particular, diet determines fish impact on ecosystem functioning through trophic interactions with other food-web components (18, 19) and, consequently, on nutrient cycling (20, 21). Diet also mediates habitat requirements because some resources are restricted to particular habitats: e.g., epilithic algae (22).

Mobility. Mobility determines energy needs, with mobile species requiring a lot of energy by mass unit compared with sedentary species (23). Mobility also affects the spatial extent at which fishes control their resources and transfer nutrients, especially between habitats around reefs (24, 25).

Period of the Day at Which Fishes Are Active. The period of the day at which fishes are active has implication on the trophic role a species plays in the food web through both bottom-up controls [i.e., the set of resources it can target (26)] and top-down controls (i.e., the susceptibility it has to being preyed upon). For instance, most nocturnal species escape predation from active predators during the day and vice versa (27).

Level in the Water Column. The level in the water column occupied by fish is critical for determining fish ecological niche as it influences the set of potential prey available (14) and fish impacts on nutrient transfer between vertical strata (28).

Gregariousness. The gregariousness of fish is an important component of fish behavior that determines the ability of (*i*) escaping from predation (29, 30) and (*ii*) impacting local ecological processes, with schooling species inducing potentially massive nutrient cycling and resource depletion (25, 31, 32).

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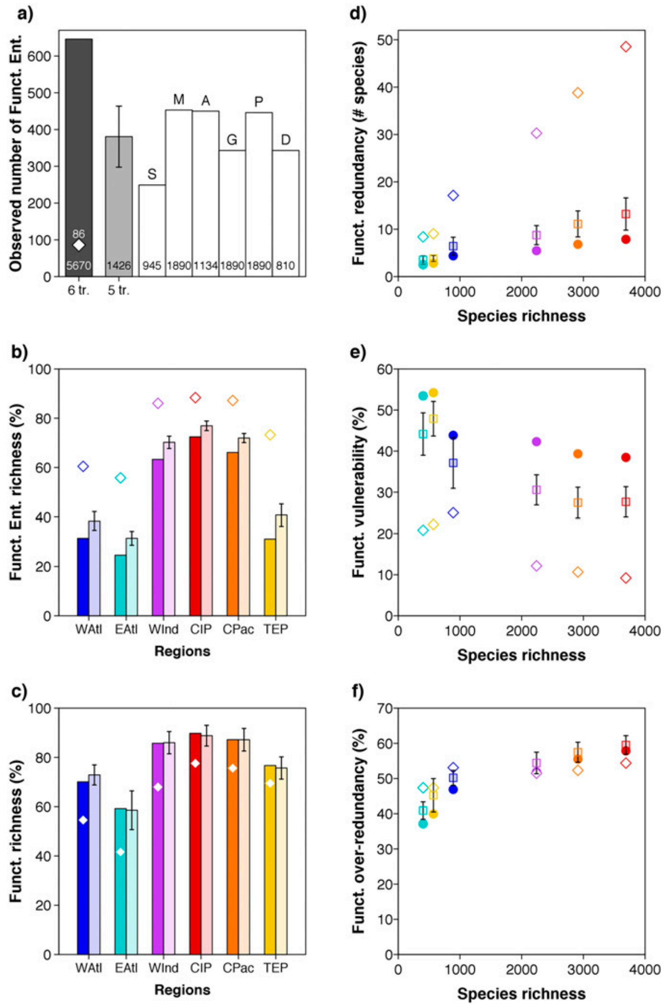

Fig. S1. Sensitivity analyses. First, we considered the six possible combinations of five traits out of six. Second, we decreased the number of categories considered for each trait (*Materials and Methods*). For each of these seven changes in trait combinations, we computed all of the indices presented in the manuscript. (*A*) Number of functional entities (FEs) in the global pool of 6,316 species. The dark bar on the left shows the pattern observed with six traits. The white diamond shows the decrease in number of FEs after reducing the number of categories per trait (*Materials and Methods*). The light-gray bar on its right shows the mean value obtained with five traits only (± SD). The six cases with five traits are shown with empty bars on the right with the name of the trait removed at the top (S, size; M, mobility; A, period of activity; G, gregariousness, P, position in the water column; D, diet). The potential number of FEs given the number of traits and number of categories in each trait is shown at the bottom of each bar and above the white diamond. (*B*) Functional entities richness in each of the six regions, expressed as a percentage relative to the total number of FEs present in the global pool of species (as in Fig. 1, *Top*). For each region, the full-colored bar shows the richness computed with six traits. The diamond above each full-colored bar shows the richness when considering fewer categories per trait. The light-colored bar on the right of each full-colored bar shows the mean value (± SD) with five traits only. Color codes for regions are as in Figs. 1–3. WAtl, Western Atlantic Ocean; EAtl, Eastern Atlantic Ocean; WInd, Western Indian Ocean; CIP, Central Indo-Pacific Ocean; CPac, Central Pacific Ocean; TEP, Tropical Eastern Pacific Ocean. (*C*) Functional richness in each of the six regions computed as the volume of the functional space filled and expressed as a percentage relative to the functional space filled by the global pool of species (as in Fig.1, *Top*). The white diamond within each full-colored bar shows the richness when considering fewer categories per trait. The light-colored bar on the right of each full-colored bar shows the mean value (± SD) with five traits only. (*D*) Functional redundancy (mean number of species per FE) along the species richness gradient (as in Fig. 2*A*). The values obtained with six traits are represented with colored points. The values obtained with fewer categories per trait are represented as empty diamonds. The mean value obtained with five traits (± SD) is symbolized by the light-colored squares. Color codes for regions are as in *B*. (*E*) Functional vulnerability (percentage of FEs with only one species) along the species richness gradient (as in Fig. 2*C*). (*F*) Functional over-redundancy (percentage of species in excess in the FEs with more species than expected under even distribution) along species richness gradient (as in Fig. 2*D*).

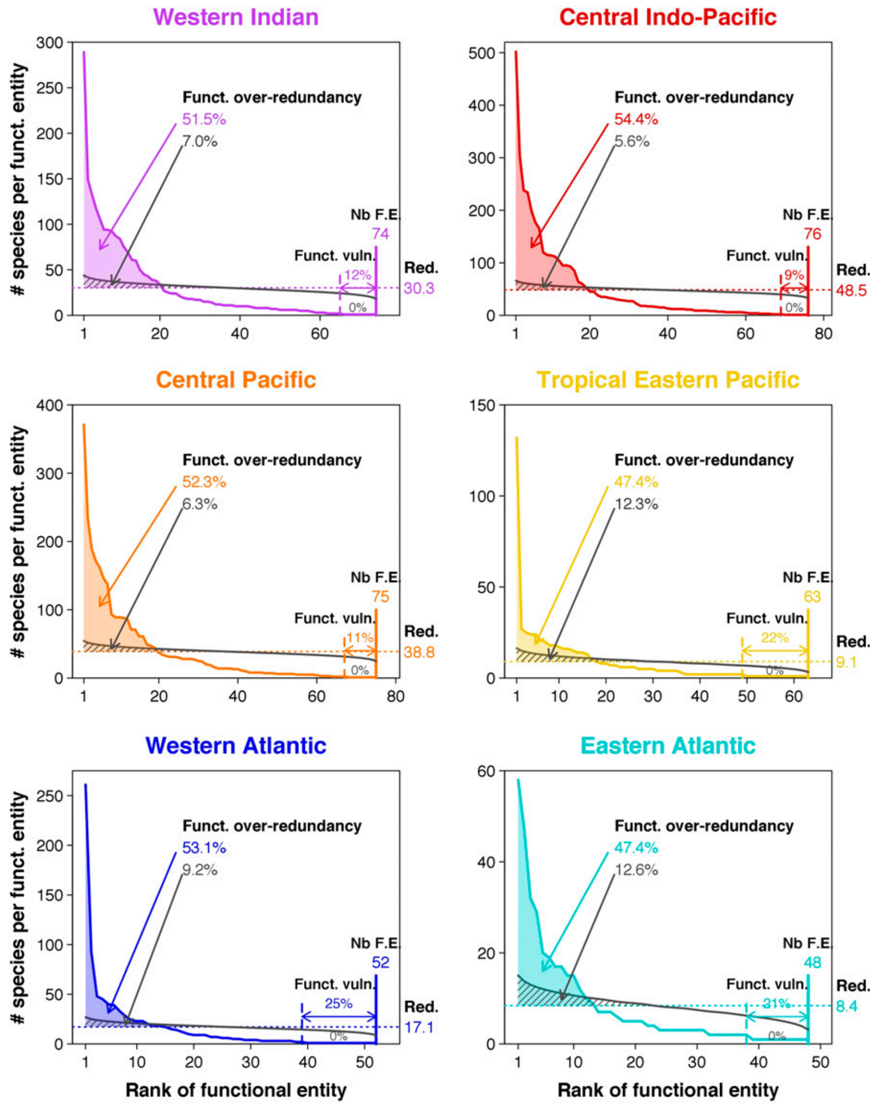

Fig. S2. Functional over-redundancy and functional vulnerability in six tropical-reef fish faunas using a crude categorization of traits defining 86 functional entities instead of 646 (in Fig. 3) for the global pool. The distribution of fish species into functional entities (FEs) is displayed for each fauna. The number of FEs ("Nb F.E.") present in each fauna is shown at the bottom right of the distribution. Functional redundancy ("Red.") (i.e., the mean number of species per FE) is illustrated by the horizontal dashed line, and the value is provided on the right margin of the panel. Functional vulnerability (i.e., percentage of FEs having only one species) is illustrated by the horizontal colored line with arrows. Functional over-redundancy, the percentage of species in excess in FEs having more species than expected from functional redundancy, is colored. The expected distribution (under a random assignment of species to FEs) is represented by the gray line, with the corresponding values of functional over-redundancy and functional vulnerability in gray.

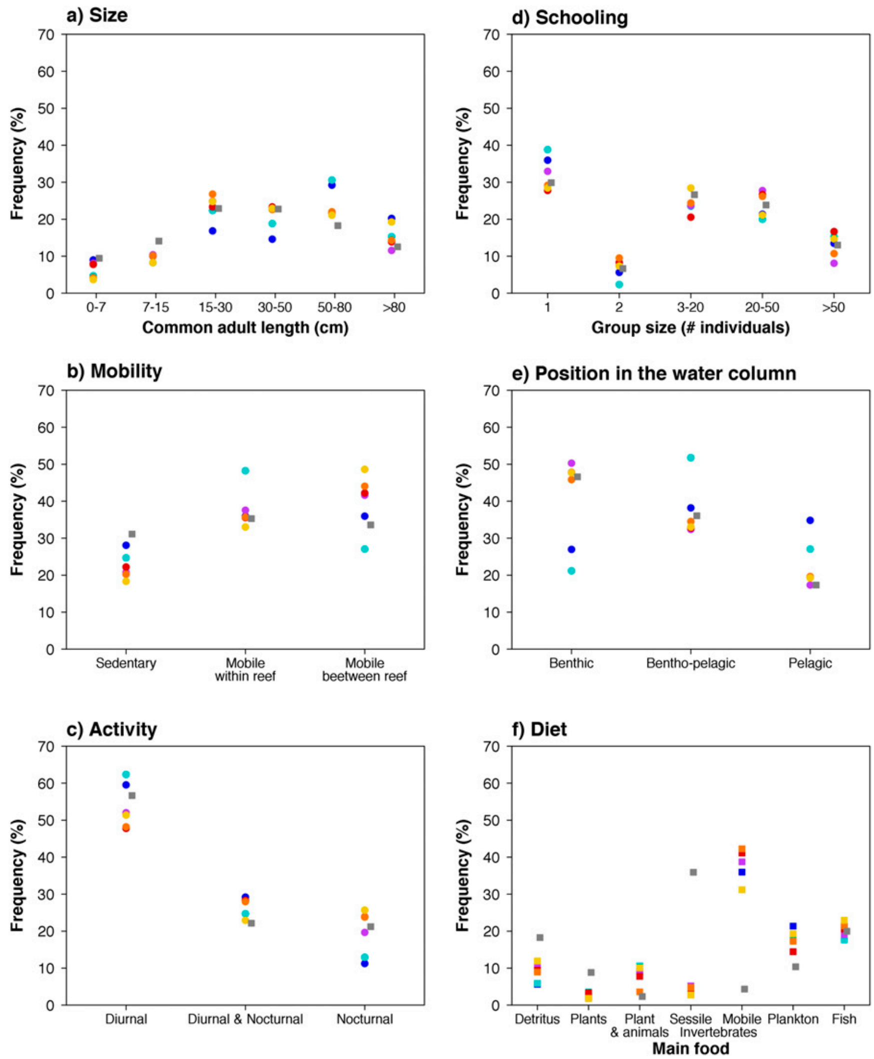

Fig. S3. Frequency of trait categories among vulnerable functional entities. The frequency of trait categories among the functional entities being vulnerable (i.e., represented by only one species) in each region is shown with colored points (color codes are as in Figs. 1–3 and Fig. S1). The frequency of each trait category in the global pool of functional entities is shown as gray squares.